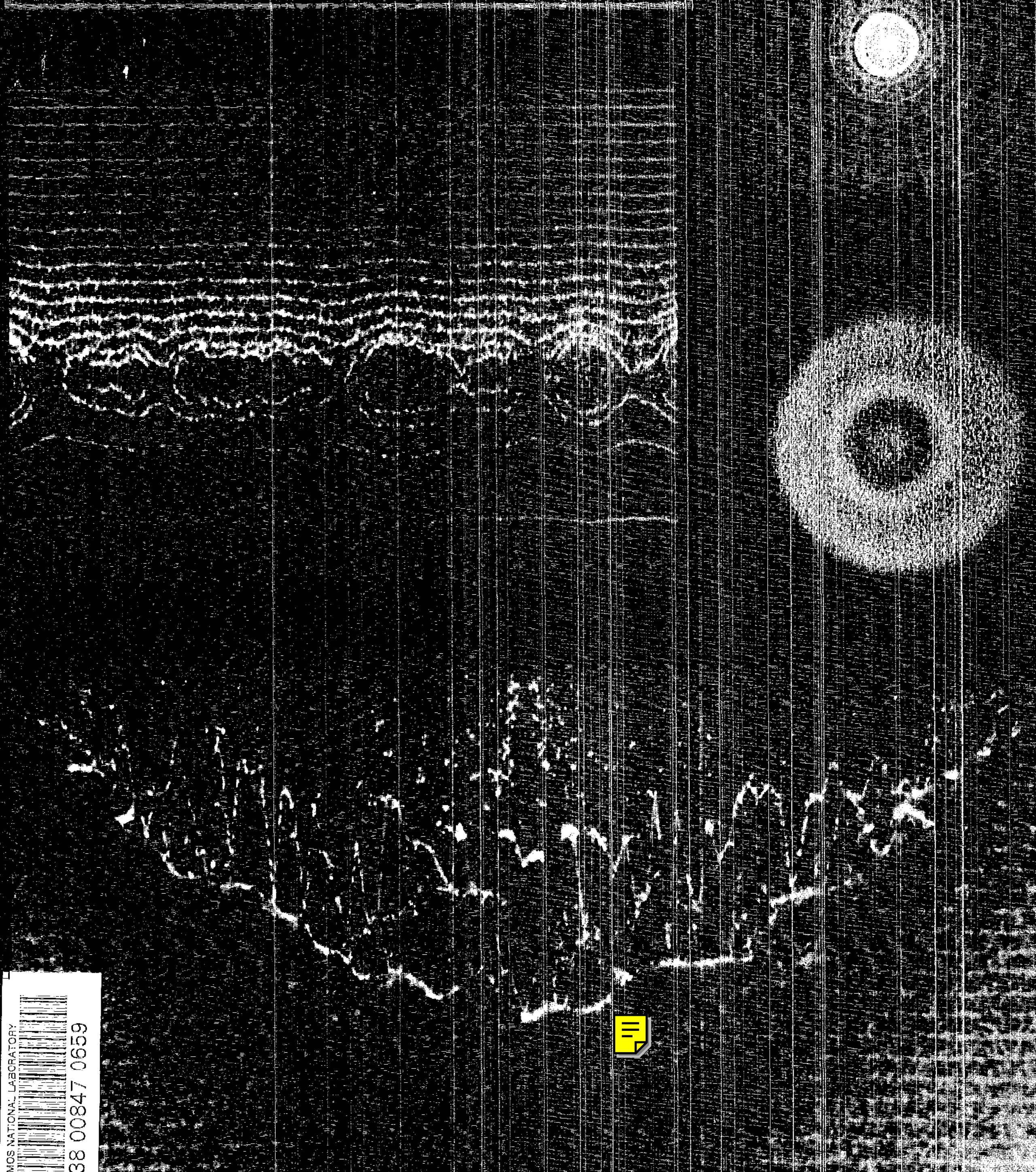
THE ATOM

Los Alamos Scientific Laboratory April, 1971



"Of Mice and Men"

By Bill Richmond

"The barn should be locked before the horse is stolen. But you should be sure that you have a horse first."

These are the words of John "Jake" Spalding, radiobiologist in Group H-4 at the Los Alamos Scientific Laboratory, in expressing his belief of current radiation standards.

Spalding says, in his opinion, he and his associates have found that long-term genetic effects from radiation are nil.

"We are not saying that ionizing radiation in large enough doses will not cause mutations," Spalding says, "because it will. What we are saying is that these mutations are generally lethal and are not passed on to succeeding generations."

Spalding's research team has recently terminated a 12-year study involving the irradiation of 45 generations of mice. A comparable study of man would stretch back about 1,350 years.

Spalding's program is not the only one of its kind. Actually, radiation has been studied more exhaustively than any other environmental change. LASL and other laboratories—as well as numerous individuals in various research organizations—have been studying the effects of radiation for more than a quarter of a century. However, Spalding's project covered more generations of mammals than any other similar study.

The program was formally terminated after 45 generations because, "the results of this and similar studies have been very negative, thus, experiments with more scientific sophistication are required to detect any possible induction and accumulation of radiation-induced genetic injury," the radiobiologist said.

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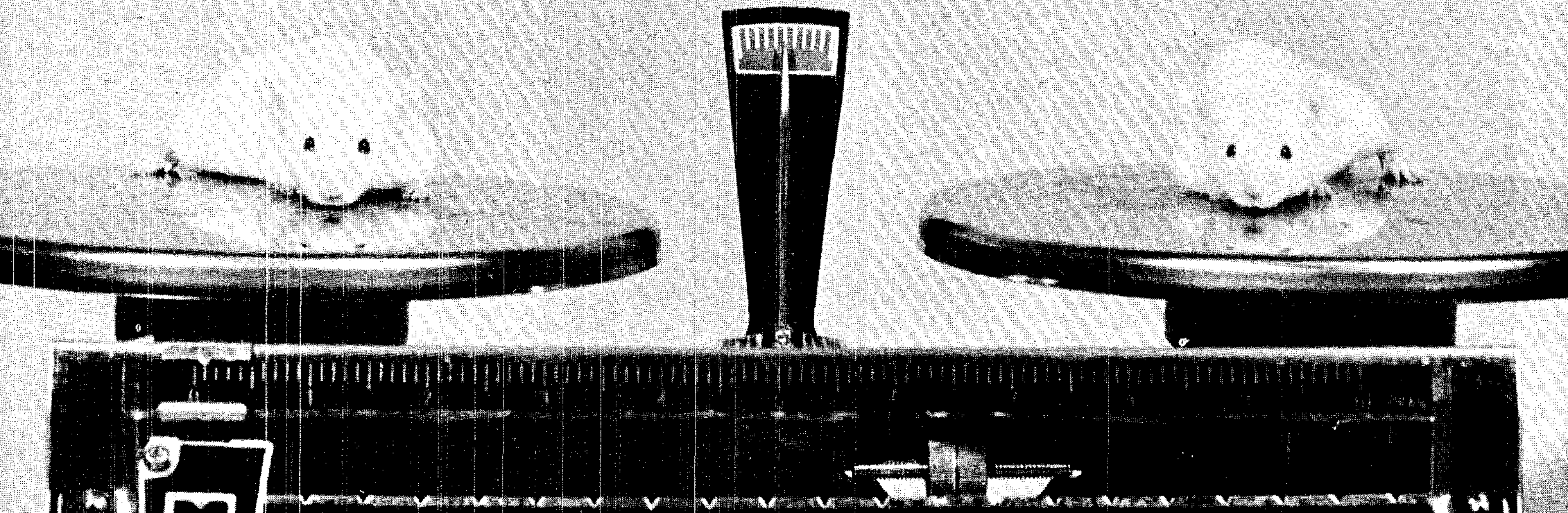

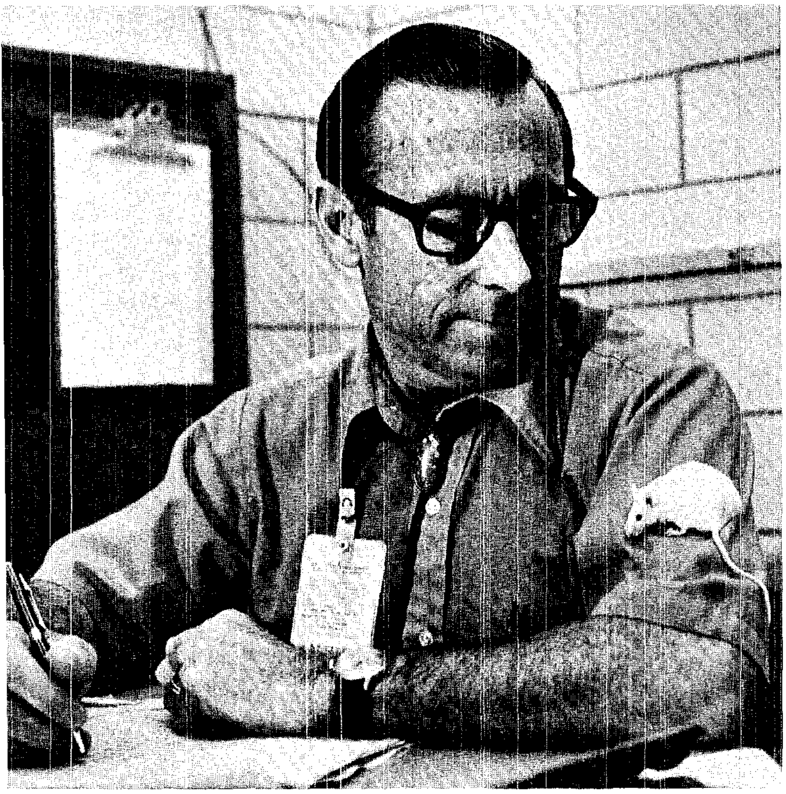

John Spalding, H-4 radiobiologist, is shown with one of his control-group mice.

"We took two lines of mice, all originally from one litter, then separated them into control and irradiated groups," Spalding said.

"In the irradiated line, each male in each generation received 200 rads of x rays to the whole body. This is approximately one-third the lethal dose for mice and about 5,000 times their natural background dose." A rad is a unit of exposure to ionizing radiation, while the lethal dose, normally expressed as LD-50, means that if 100 mice received 600 rads the chances are that 50 of these mice would die. (The LD-50 for man is approximately 400 rads). An average chest x-ray will expose a patient to approximately .03 rads.

The irradiated males were placed with their sisters until they produced the next generation. And each male in each succeeding generation received 200 rads to the whole body.

"The females were not exposed to irradiation," Spalding says, "because 25 rads is enough to cause them to become sterile. This, of course, would have ended the program."

The control line mice received no radiation but were maintained at the same degree of inbreeding as the irradiated line.

"We mated 75 breeding pairs in each line of each generation and made comparative studies between the irradiated and control lines at each five generations," Spalding said. "We studied such things as life span, growth and development, litter data, activity, radiation resistance, blood characteristics, visible mutations and other factors. It is commonly known that developing mammalian germ cells are among the most radiosensitive cells."

The average life span and death distribution were the same in both the control and irradiated groups.

The results from other countries of experimental research on the possible genetic effects of exposure to ionizing radiations have failed to show accumulated radiation-induced genetic injury harmful to succeeding generations, the radiobiologist says.

Skeptics may cry: "What is the relationship between lower mammals (mice) and man?"

Lower mammals have many of the same physiological characteristics as man and, also, basically the same genetic inheritance characteristics as man. Whenever the Food and Drug Administration, or other groups, wish to determine if some-

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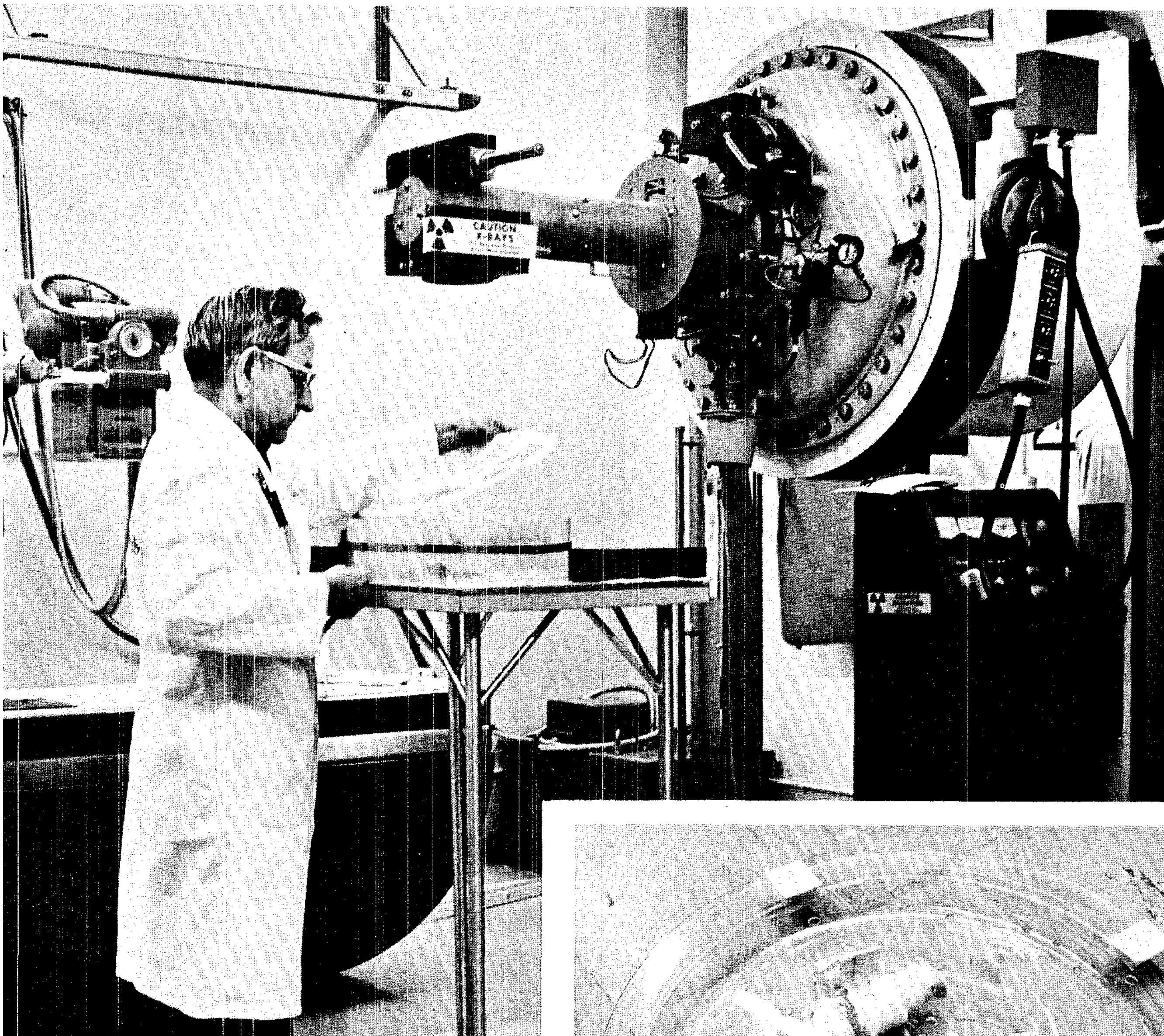
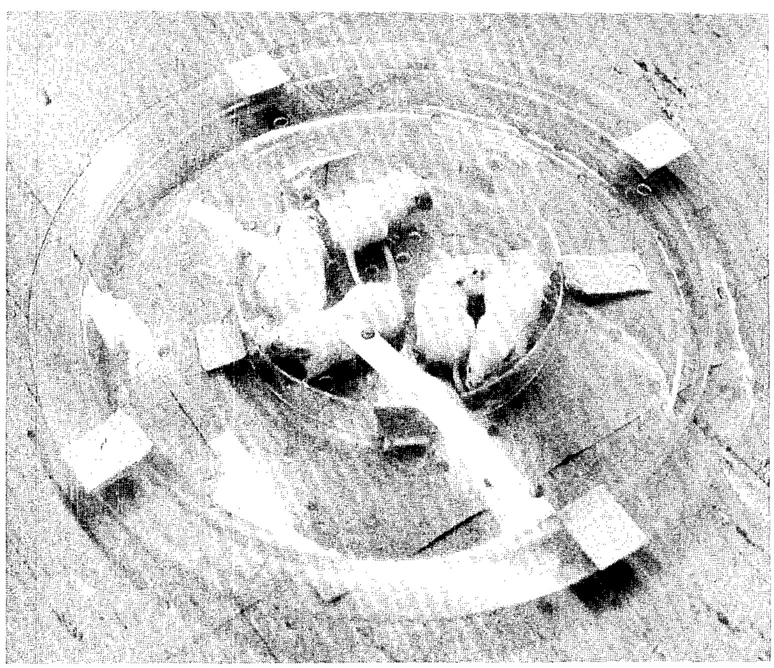




Ogden Johnson, H-4, prepares to irradiate a group of mice with x rays. The picture insert at right shows how the mice are arranged in the plastic holder.

Spalding and Mary Brooks of H-4 work in one of 13 similar rooms which have cages enough to hold a total of 50,000 mice.

thing is safe for man, they first test it with rats and mice.

In some aspects, the results obtained from experimentation with laboratory mice are more reliable than statistical data on man. With the mice in the laboratories, the scientist can exclude complicating environmental variables such as airborne and food-chain contaminants and medical diagnostic and therapeutic effects. This limits the results to the investigation of the particular agent or environment in question. This procedure cannot be followed with man, particularly with "after the fact" statistical data.

Also, the natural background radiation for mice in the laboratory can be more accurately plotted during their lifespan. This can be difficult for man. The natural background radiation consists of two primary sources, cosmic rays and natural radioactivity. Natural radioactivity is further subdivided into two types: External (from uranium, thorium and associated decay products in the earth's crust or atmosphere); and Internal (from potassium-40, radium and its decay products, and carbon-14 in the body).

How does Spalding square his findings with the statements made by some persons—including a few other scientific types—of "increasing evidence of genetic effects of small doses of radiation?"

He answers, "The so-called 'increasing evidence of genetic effects of small doses of radiation' seems to be a mood of the times rather than a fact.

"Just as you go to a doctor for a medical problem rather than a plumber, so does the establishment go to a radiobiologist for radiation effects standards.

"Even the Soviet Geneticist M.D. Pomeranteseva has concluded from her research that genetic injury induced by exposure to ionizing radiation is generally of a lethal nature and is thus not perpetuated in the germ line of the progeny of irradiated progenitors.

"Present standards are established on the basis of data obtained from years of experimentation by highly competent scientists whose only interest is in the truth, and who are motivated by scientific curiosity and concern for the safety and welfare of future generations." Spalding has seen no evidence to suggest that our present radiation standards for genetic effects are out of line.

In research there are two approaches:

--You set out to prove something.

--You set out to find out something.

Obviously, the latter approach, particularly in the scientific fields, is the more objective, and this is the approach that Spalding and his fellow researchers took.

The possible consequences to man and his offspring, resulting from changes in the environment, are of great concern to both lay and scientific communities. Speculations on the possible biological effects of exposure to low doses of ionizing radiations, particularly from a genetic standpoint, are prevalent in the nonscientific literature.

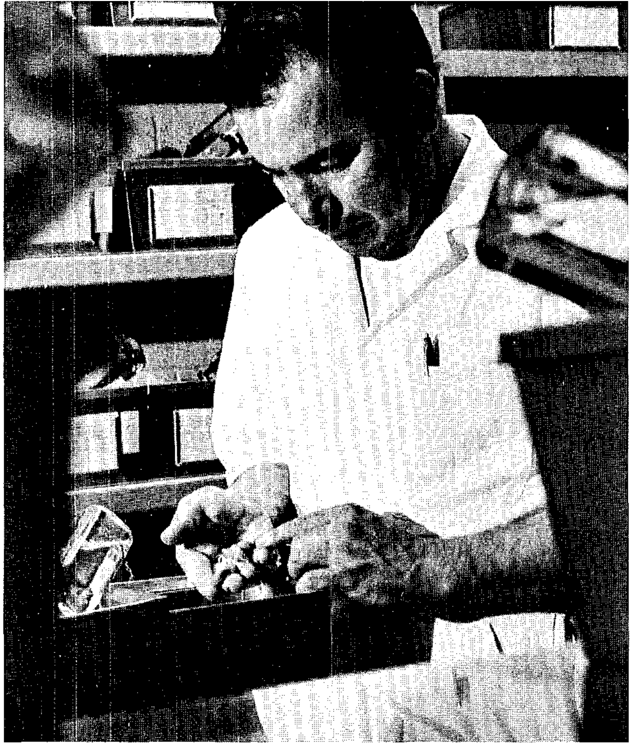
Although present environmental levels of man-made ionizing radiations are insignificant relative to natural background levels, Spalding said, the fear and mystique surrounding the term "ionizing radiation" make it a common subject of public anxiety and concern.

"A persistent theory is that one of the genetic effects that may be expected in first-generation offspring of irradiated parents is life shortening caused by radiation-induced mutations.

"The results of this and other studies have given no support to the thesis that radiation-induced genetic injury will accumulate and shorten the lives of progeny of irradiated progenitors. In fact, these data suggest that a single gene locus may play a significant role in determining longevity within a species. This is the H-2 locus.

"The negative nature of this long-term study and other reports on the genetic effects of ionizing radiation provide evidence that cumulative radiation-induced genetic injury is insignificant. If life-span shortening from a radiation-induced genetic decrement cannot be detected in offspring from 45 generations of mice all exposed to over 5,000 times natural background radiation dose, it seems unlikely that exposure of man to twice his natural background radiation level, though conforming to exposure guidelines set by the various national and international committees, would have a measurable impact on future generations."

Although Spalding's major project was carried out with intensive inbreeding (which, in theory, is an undesirable way to accumulate genetic injury), other of Spalding's studies and those of other researchers using different breeding methods have produced similar negative findings.



Jose Atencio of H-4 counts the members of a new generation of mice.

Variations in radiation sensitivity within a species have been known for more than 20 years. A major factor in understanding radiation injury and repair in the biological system is first to understand control of radiation sensitivity, Spalding said. Recognizing that the genetics of radiosensitivity are fundamental to most problems in radiobiology, researchers have devoted much effort to various aspects of radiosensitivity variations between and within strains of animals.

According to Spalding, a difference in radiosensitivity was discovered between two lines of mice involved in a comparative radiation resistance study he did several years ago relating to the ability of mice to withstand protracted gamma radiation stress. The difference was most pronounced when a continuous low-intensity, gamma-ray exposure was used. Furthermore, dose rate and age studies suggested that the radioresistance factor was associated with the bone marrow or blood-forming tissues.

It was later learned that the H-2 genotype was

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subdivided into H-2^k and H-2^f sublines. Since the two lines differed in their radiosensitivity as well as their H-2 genotype, it seemed reasonable to test whether H-2 differences in these sublines were associated with radiosensitivity. Since these mice were derived from a common line with over 50 generations of inbreeding, Spalding said, they probably differed from each other primarily at the one locus tested.

Over 1,000 mice have been used to determine to what extent the H-2 locus may affect radiosensitivity. The subjects were exposed continuously to cobalt-60 gamma rays until they succumbed. The dose rate was four rads per hour.

Differences in sensitivity were determined by comparing mean survival times of the two sublines, values being calculated on the actual exposure time. Several mice were sacrificed a few hours prior to radiation death and a postmortem examination was performed to establish the cause of death in mice allowed to die after gamma ray exposure. Additional mice from each H-2 subline were exposed to the same gamma ray exposure conditions for 21 days only and were then allowed to recover. These mice were used to study the comparative effect of gamma-ray exposure on the bone marrow during exposure and recovery.

There was a definite difference in the mean survival times of the two sublines. The H-2^f subline had a survival period of approximately 795 hours as compared to 909 hours for the H-2^k subline.

These investigations suggest a relationship between radiation resistance and the H-2 locus that might answer the question of whether a single gene locus can influence resistance sufficiently to be important.

The results point to a single genetic factor which plays a significant role in controlling radiation of the blood-producing tissues in the mouse. This resistance seems to be expressed as a difference in the threshold dose (minimum dose of radiation that will produce a detectable biological effect) and the dose rate of radiation required to produce a block to the blood-producing system.

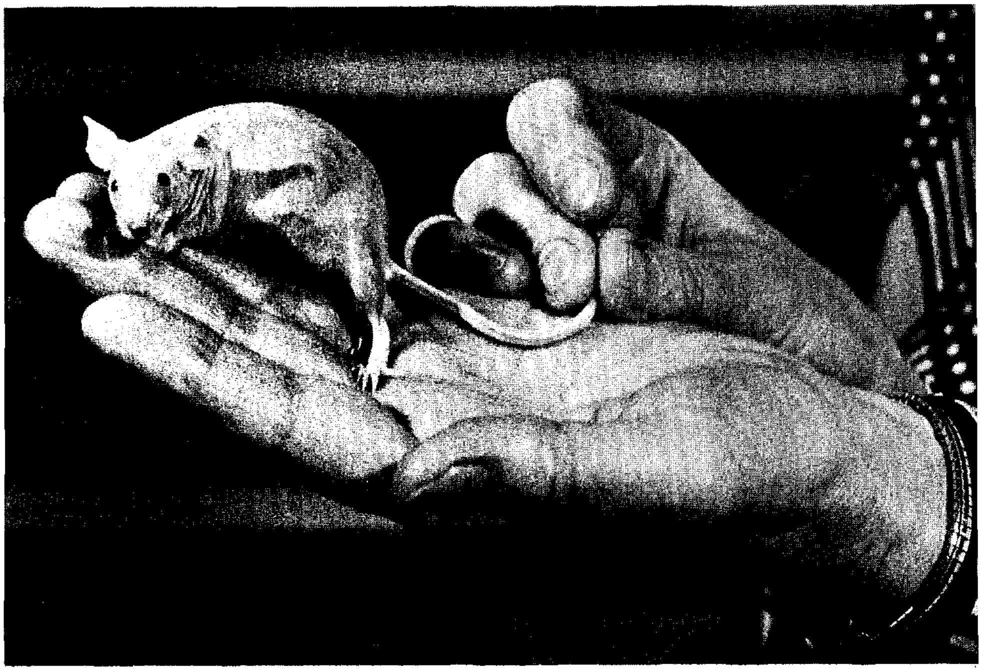
Spalding says, "The positive identification of a single locus which has a strong influence on radioresistance of the single, most sensitive tissue associated with events leading to radiation lethality (the bone marrow) would be a significant step toward understanding the kinetics of radiation injury and repair."

When asked if any type of mutation appeared in his 12-year study of the radiation effects on mice, Spalding admitted there did.

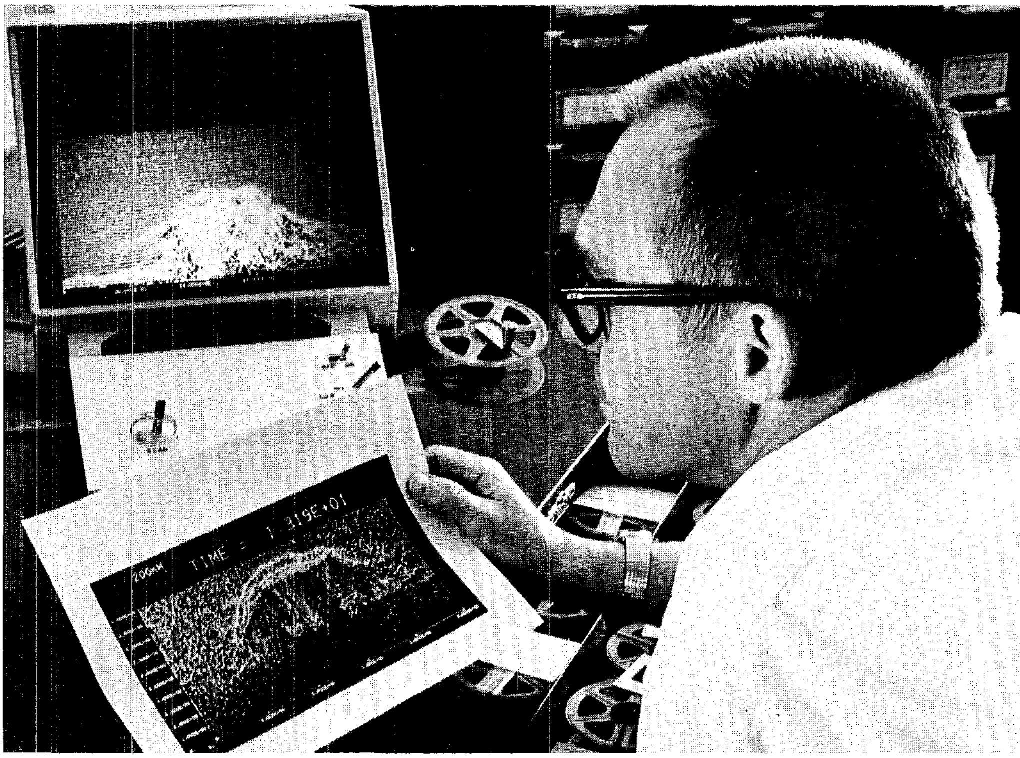
"A spontaneous mutation for hairless showed up in one of the control groups in the 11th generation. However, spontaneous mutations, although rare, do occur in all species from time to time."

Since the mutation occurred in the control group—which received no radiation—perhaps a case could be made that radiation prevents hairless mutations.

This mouse is a member of the hairless generation.



Donald Dickman, C-4, compares a color print with a transparency on his office viewer.



Computer-Generated Color Film

Photos by Ivan Worthington

Ever since the modern-day computer peered over the technological horizon, man has been hell-bent on getting it to do more faster. He endowed the computer with the capability of producing graphic information and in a short time computer-generated black and white film became commonplace. From here it was only natural to reach for color film production.

As a result, computer-generated color film is now in its infancy. The know-how necessary to produce it hasn't been so much a problem as the know-how to produce it economically enough so researchers can afford to use it. The big economic factor is time. On large industrial computers every minute is valued at several dollars.

A team of scientists at the Los Alamos Scientific Laboratory felt that in order for color-film production to be economically feasible, it should require no more computer time than an equivalent black and white run and should not sacrifice sharpness or clarity. With this in mind the scientists came up with a technique of generating color film that is currently being put to advantageous use at Los Alamos.

"There are several advantages to using color in basic research," said Donald Dickman of C-4. "First of all, color has a distinct impact that black and white doesn't have. Wherever our color film has been shown, the reaction has been startling and favorable. We can do

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Magnetic tape for the production of color film is generated on such complex computer systems as LASL's CDC-7600.

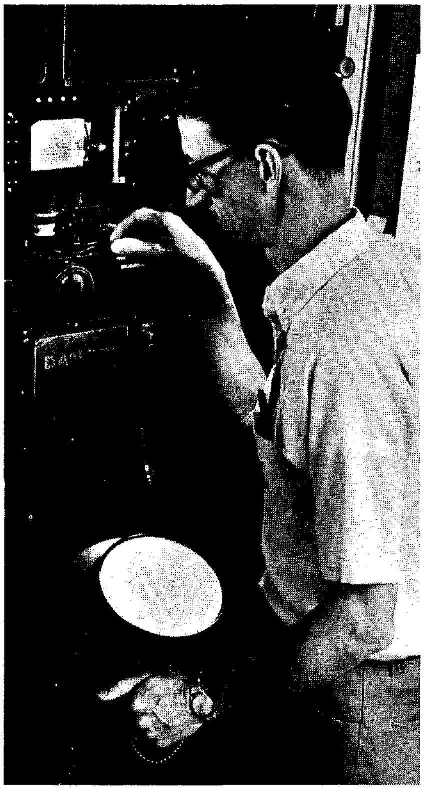
On the Cover

The four color photographs on the cover of this issue of The Atom were made from computer-generated color film. Of the two larger photographs, the top one represents a Sherwood plasma run. It was one of the Laboratory's earlier attempts in producing color and was done by presensitizing the background with blue light. The photograph at the bottom shows expanding gas in partially ionized air. The gas is represented by red particles and air by green particles. Contour lines for magnetic fields are in blue. The other colors are a result of mixing.

Of the two smaller photographs the top one shows a polar coordinate run of expanding gas made from film that had been presensitized with blue light. The other photograph represents the cross section of a nuclear reactor fuel element and shows the distribution of the three isotopes present.

On the back cover are black and white renditions of the two larger photographs. Notice the detail with which color shows mixing of elements when compared to their black and white counterparts, especially in the bottom photograph. In this frame, a field line instability (the erratic blue line in the red portion) was not known to exist until this color run was made.

Dave Buckner, C-8, adjusts the device he developed which will position color filters in about 30 milliseconds on one of the Laboratory's SC-4020 printer/plotters. Above the filter device is the camera lens. Below, a test pattern is shown on the cathode ray tube.



things with it that we've never been able to do before. We can put more information on a single frame than is possible with black and white. The clarity with which we can show how different materials mix, for example, is impossible with black and white."

Los Alamos achievements in computer-generated color film followed a pioneer research program by Sandia Laboratories in cooperation with Stromberg-Datagraphics, Inc., in 1967. Sandia's approach and the method now being used at Los Alamos logically take-off from the black and white production methods. The information generated by the computer is on magnetic tape. The tape is fed into a Stromberg-Carlson SC-4020 printer/plotter which converts the information into a graphic display on the face of a cathode ray tube where it is photographed. In appearance, the image on the cathode ray tube is much like the image seen on a black and white television set.

Between the cathode ray tube and the camera lens, the Sandia researchers placed a color filter wheel which was driven in one direction by a stepping motor. In each quadrant of the wheel was a filter; these were red, green, blue and clear. The idea was to photograph the image on the tube through a color filter with color sensitive film. However, the filters reduced the amount of light reaching the camera lens. This factor, coupled with film-speed limitations, made it impossible to obtain adequate exposure except by "overstriking." This is a term meaning the computer repeats the information on the magnetic tape more than once. By having the computer overstrike from seven to nine times, the image was repeated a like number of times on the cathode ray tube. This allowed a longer period of time for the image to "soak" into the film emulsion.

This method produced satisfactory results but at the same time was convincing evidence that color film generation could be an expensive proposition. Overstriking on the computer and longer exposures on the printer/plotter took too much time for color-film generation by this method to be economically feasible. In addition, the time required to rotate and stop the color wheel further jeopardized the technique. Every quarter turn of the wheel required 200 milliseconds (one-fifth of a second). Use of the filter in the third quadrant then, required 600 milliseconds to move into position and stop.

In 1968, Los Alamos scientists became interested in color film production. They studied Sandia's method and other approaches, such as tinting which had been attempted at other computer installations. Interest, however, soon waned because of the necessity of overstriking to obtain the best results.

"In the spring of 1969 we were

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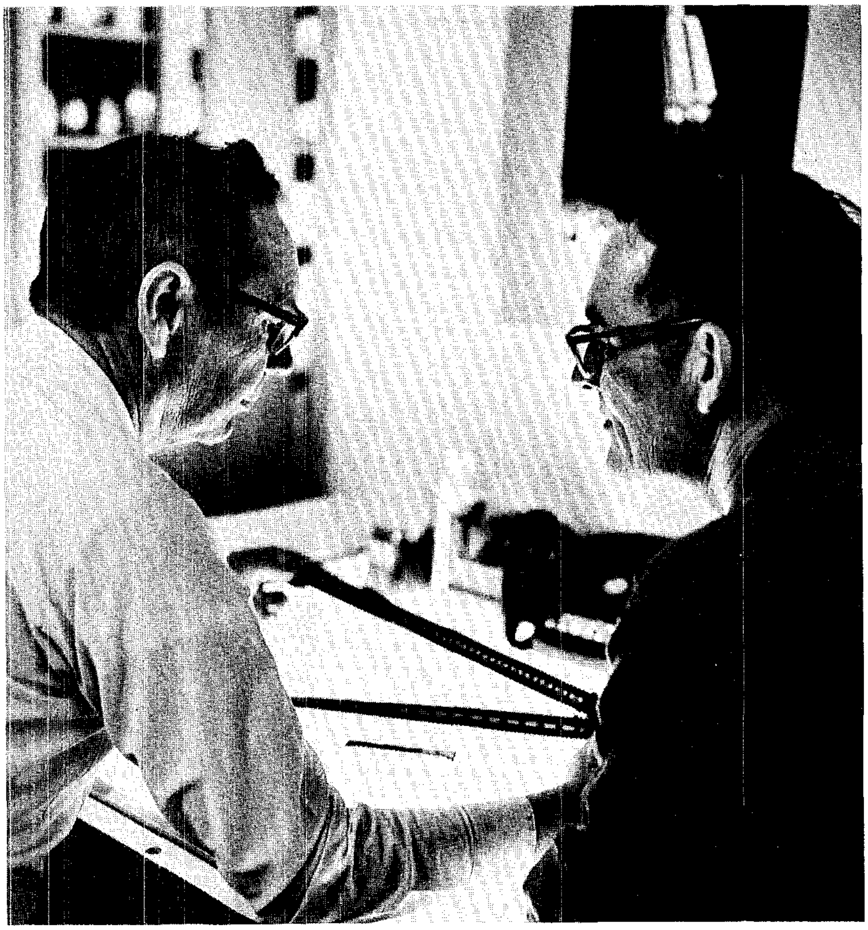
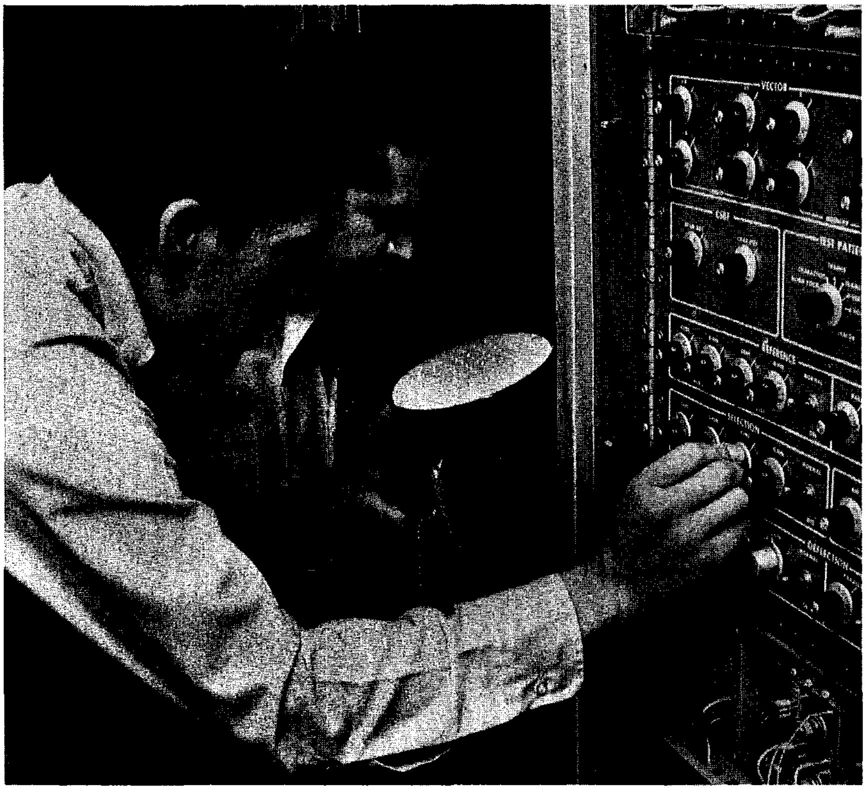
Bob Crook, ISD-7 group leader, and Frank Berry, also of ISD-7, study film that has undergone extended-development processing.





Dan Torres and Fred Salazar, both C-8 maintenance engineers, calibrate the cathode ray tube on an SC-4020 printer/plotter recently put into operation.

approached by Dick Morse of P-18 about the possibility of color production for Sherwood and high altitude phenomenology," Dickman said. "We said we would do it if we could find a way of doing it without overstriking."

A cooperative effort among Groups C-4, C-8 and ISD-7 began, aimed toward obtaining color film with a single computer strike. One of the first methods attempted was to "presensitize" film on the printer/plotter. This means the film was exposed to light through a color filter. Upon development, the film would have a background of the color to which it was exposed. David Buckner of C-8 had presensitized some film while conducting a study of various color filters. Dickman suggested that an image produced by a single computer strike might be seen against these backgrounds.

Presensitizing was tried with the colors green, red and blue. Blue showed the most promise but was still unsatisfactory. Bob Crook, ISD-7 group leader, and Frank Berry, also of ISD-7, experimented with extended-development of the film and produced better results.

Presensitizing film was still not the answer to economic generation of color film. By using one color to provide a background, only three were left to do the plotting. In addition, "sweeping" the background took an inordinate amount of time on the printer/plotter. The money saved by using only a single computer strike would be spent in presensitizing film on the printer/plotter.

At the same time, Buckner was studying filter positioning devices. He built a color wheel whose filters could be positioned in 50 milliseconds. The device, however, required large amounts of electrical power and heating of associated electronics was a problem.

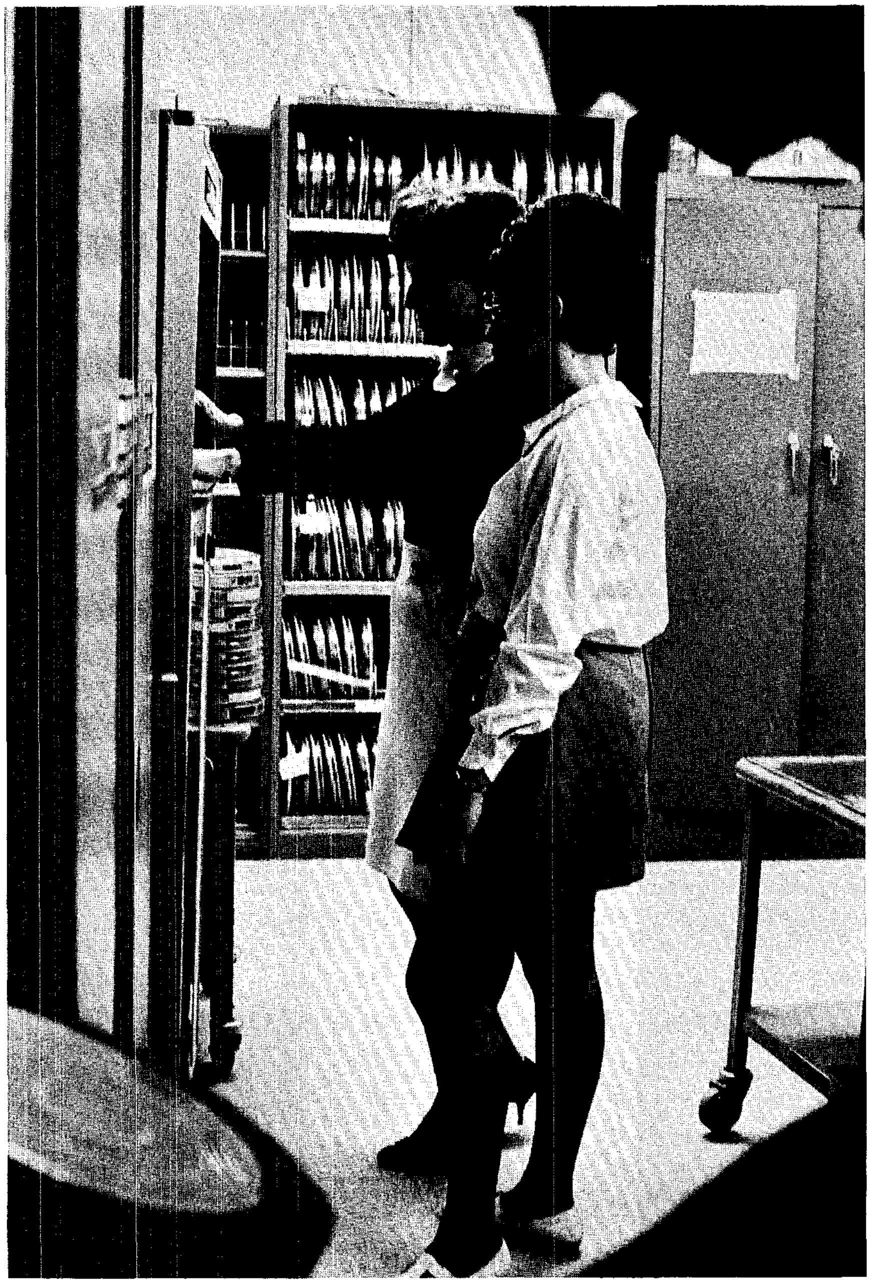
Buckner discarded the idea of using a wheel for positioning of the filters. Instead he built a device in which each filter was mounted on a magnesium arm. Each arm was driven by a solenoid and could position a filter in about 30 milliseconds (including 10 milliseconds during which the filter assembly oscillated after it was moved into position).

New filters were installed in the device to allow more light to pass through, the camera lens aperture was changed to admit more light (from f/5.6 to f/3.5) and was later replaced by a better-quality lens, a brighter-image cathode ray tube was procured, and extended development of the film was increased from a "one-stop push" to a "two-stop push." These are development procedures designed to compensate for underexposure of film. A one-stop push essentially doubles the speed of the film and a two-stop push quadruples it.

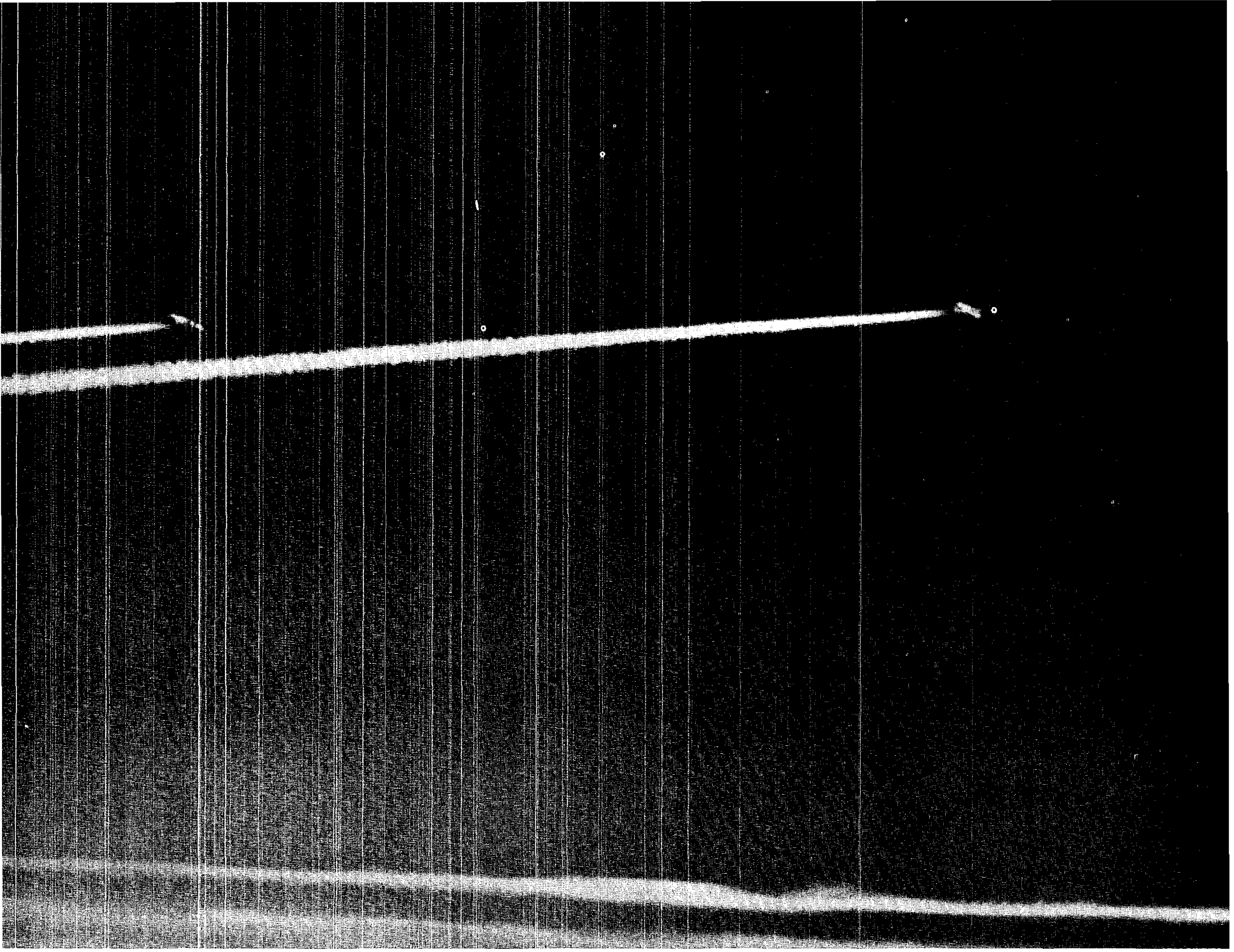
Because of equipment limitations at the Laboratory, processing of computer-generated color film is being farmed out, and because of the necessity of having it processed in a restricted area, it is presently being sent to Kirtland Air Force Base in Albuquerque.

As a result of its efforts, LASL now offers its scientists computer-generated color film which takes no longer to produce on the computer than black and white, and increases printer/plotter time by a factor of only two and a half per cent. Color is being produced on 16-millimeter motion picture film and 35-millimeter still camera film.

Even this is not the ultimate. Los Alamos scientists are currently experimenting with new techniques and instrumentation that show promise of trimming production time and costs even more. Buckner is working toward completion of a new device which will offer a selection of 10 color filters and will position any one of them within 14 milliseconds. A newly developed cathode ray tube is on order which will display images with greater resolution and with variable intensity. These improvements and the removal of a pellicle which cuts down on the light allowed to pass through to the camera lens are expected to eliminate the necessity of extended-development processing.



Jean Marrs and Betty Lopez, both of C-1, thread a magnetic tape into the SC-4020 printer/plotter.



The two B-57's used in the contrail studies begin flying a racetrack pattern to build up water vapor equivalent to several SST's. (Photo by John Wolcott)

"Piggyback" Experiment on a Gree

One of the most controversial aspects in the current debate on whether or not to build the American supersonic transport is the possible effects of the aircraft on our environment. Scientists have speculated that it would be possible for large numbers of the high-flying, supersonic planes to affect the earth's weather and climate. This they say would come about by altering the "greenhouse" effect of our atmosphere.

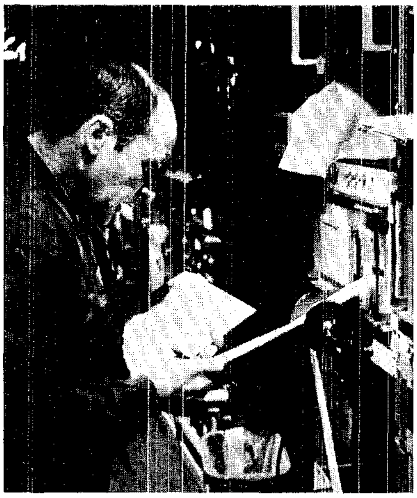
Earth's atmosphere is like the glass roof of an ordinary horticulture greenhouse which allows sunlight to stream in freely, but does not allow the heat released by plant life to stream out. Our atmosphere too allows sunlight to come in, but it tends to trap heat constantly being emitted by surface material of the earth. This accounts for the warm temperatures on earth that are crucial to our existence.

The roof of the earth's greenhouse consists of a delicate balance of gases, including water vapor. Water vapor is also one of the combustion products of jet engines. Other combustion products include carbon monoxide, hydrocarbons, carbon particles, sulfur oxides, and

Mission Commander Robert Peterson, second from right, talks with members of the contrail study group at a pre-flight briefing.

Dick Tatro, J-16, records data aboard the NC-135 aircraft.

Photos by Bob Harper



nhouse Roof

some that are the result of additives used to inhibit the growth of organisms in the fuel tanks and to prevent ice formation.

It is in the second layer of our atmosphere that the SST would fly. This is the stratosphere which begins about 30,000 feet above sea level at the poles and about 70,000 feet over the equator. Unlike the troposphere where we live, the stratosphere is characterized by an almost complete absence of wind and other weather phenomena. Because of this absence, foreign matter has been known to remain suspended for periods of time ranging from one to two years.

Opponents of the SST believe that in addition to the water vapor nature introduces into the stratosphere, large numbers of supersonic transports would inject appreciable additional amounts into this layer of our environment. The question they pose to those who must weigh the advantages and disadvantages of building the SST is, will the water vapor and other combustion products from the transport's huge engines upset the balance of gases making up the roof of our greenhouse so as to alter the earth's temperature and climate?

For the time being this speculative question must remain unanswered. Too little is known about the behavior of jet-engine combustion products in the stratosphere to accurately assess the SST's environmental impact, if any.

The United States Department of Transportation is responsible for finding the answer to this question. In February it partially funded a preliminary experiment conducted by the Los Alamos Scientific Laboratory which is expected to make one of the first inroads into this problem area.

The LASL experiment was conducted to make some basic measurements of the stratosphere and jet exhaust products in this environment. These measurements include temperatures and altitudes at which contrails form and dissipate in the stratosphere, and their diffusion characteristics, persistency, density, and elemental chemistry.

The goal is to provide some preliminary information that is relevant to the SST problem and to set the stage for more meaningful experiments by defining the techniques, instrumentation, analytical methods and operational procedures necessary to conduct them.

The study was a "piggyback" experiment over the northern polar region. It was dependent on the presence of aircraft with sophis-

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Eielson Air Force Base equipment is used to push the NC-135 out of a hangar before dawn.

ticated instrumentation which were stationed at Eielson Air Force Base near Fairbanks, Alaska, for use in other experiments. When not involved in their primary missions they were used in the environmental effects studies.

The aircraft included one of the NC-135 "flying laboratories" which are maintained and flown by the U.S. Air Force for the Atomic Energy Commission. Besides Air Force personnel, the crew included Mission Commander Robert Peterson, J-16 alternate group leader, and other personnel from LASL, Sandia Laboratories, EG&G, and General Dynamics. Other planes involved were two Air Force piloted B-57-F's from the 58th Weather Reconaissance Squadron. Paul Guthals, CNC-11, supervised their operation.

The role of the NC-135 aircraft was to provide photographic coverage of contrails with the use of its specialized photographic equipment. This graphic information is expected to render information on the formation and dissipation of contrails as a function of time, diffusion characteristics, density and persistency.

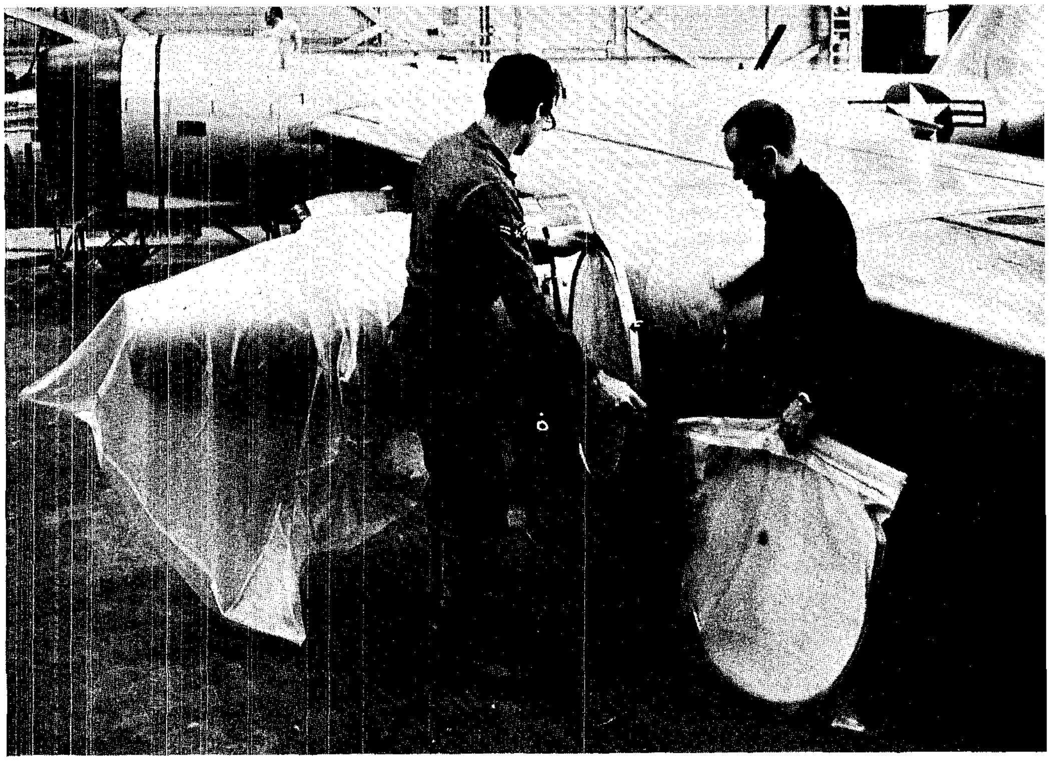
The B-57's were used to form the contrails, to observe their formation and dissipation as a function of altitude and temperature, and to collect both particulate and gas samples of the natural background of the stratosphere and of jet-engine combustion products released in this environment.

By flying the B-57's in a "shotgun" formation—one behind the other—the rear plane was able to observe the formation and dissipation of contrails from the lead plane. Particulate and gas samples of the stratosphere's natural background were collected by the lead plane and samples of jet-engine combustion products were collected by the rear plane. Both aircraft were equipped with wing-tip particulate samplers and evacuated bottles for the collection of gas samples. Analysis of the samples is expected to provide information on the chemistry of the stratosphere and of the combustion products released in this layer of our environment during the experiments. The B-57's and their specialized sampling equipment are used routinely in air sampling missions for America's test readiness program and air pollution studies being conducted at Los Alamos.

By far the most spectacular of the three flights made in connection with the experiment were the first and last. In the first experiment the B-57's flew a "racetrack" pattern to build up contrails whose water vapor content would be equivalent to that released by several SST's. This build-up was photographed from below by the NC-135. The third experiment was a repeat flight except the NC-135 was used to build up the contrails and one of the B-57's, equipped with a horizon-to-horizon camera, photographed the event from above. The photographs will be used to ascertain visible lifetime of the contrails.

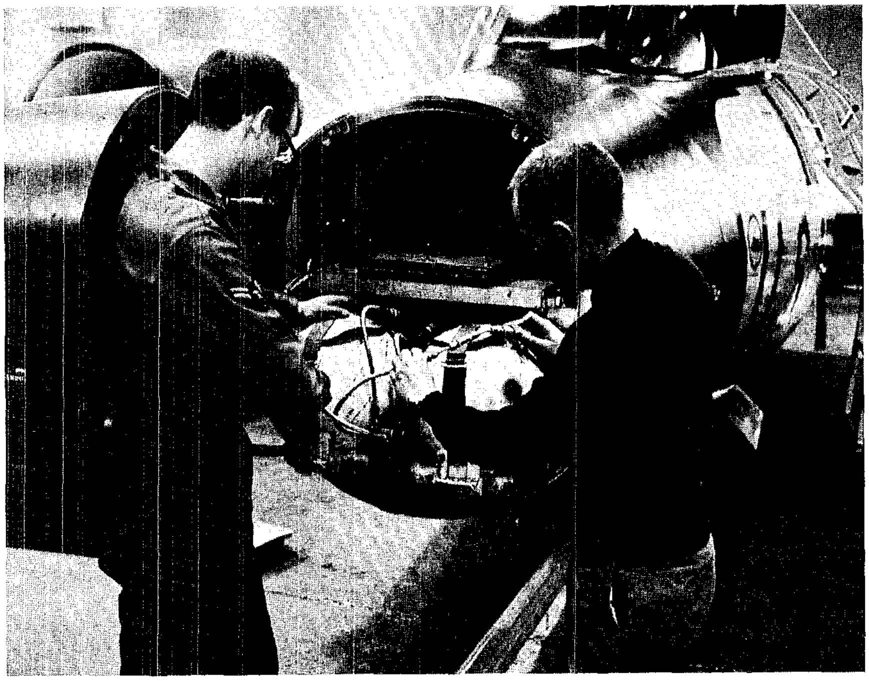
The LASL scientists had hoped to form visible contrails at altitudes between 60,000 and 70,000 feet, the cruising altitude of the SST. But, in these experiments, they formed between 20,000 and 35,000 feet.

When all the data is analyzed, the Department of Transportation will have an important tool to help this nation assess its future position on the American SST and to assess its posture toward the Russian and British-French supersonic transports.



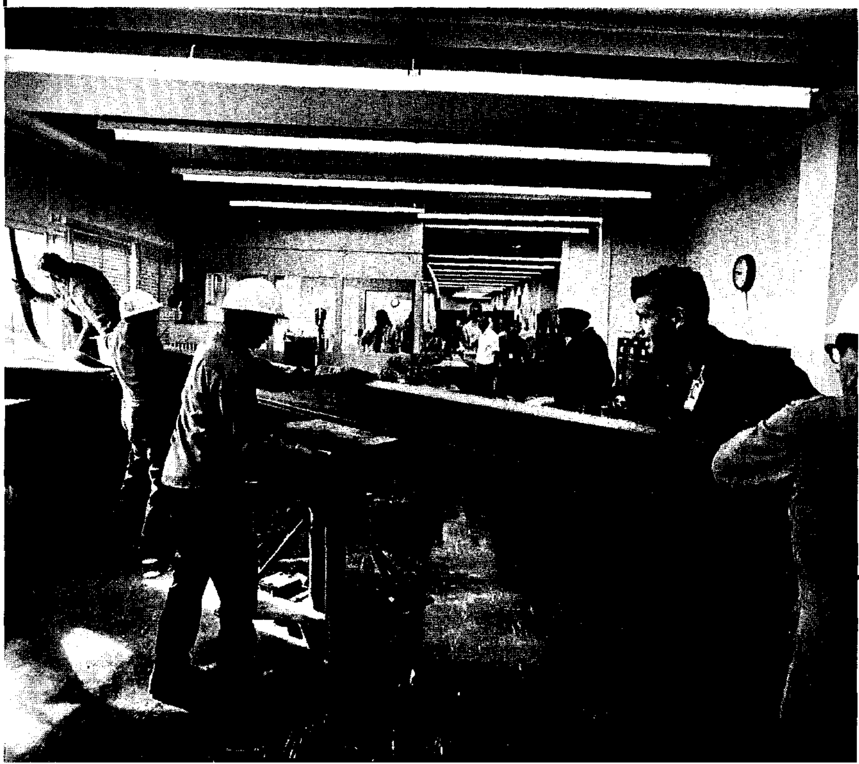
Paul Guthals, CNC-11, who supervised the operation of the two B-57's, and Airman Daniel Pandrea change a filter in one of the wingtip particulate samplers.

Pandrea and Guthals install the evacuated bottles, used to collect gas samples, in the nose of one of the B-57's.



Mail Room Section Moves

ISD-5's Mail Room section has moved from the fourth floor of the Administration building to the basement where it is closer to loading and receiving facilities and to provide more room for ISD-5's records repository. Above, Section Leader Rudy Rivera, in striped shirt, supervises relocation of his 16-member section in its new area. Left, Zia workmen bring a steel beam into the Mail Room Section's former location through a window. Steel beams were emplaced in the floor to increase its load capacity before moving in the heavy repository files.



short subjects

An estimated 750 students from the five-state area of New Mexico, Texas, Colorado, Arizona and California will tour the Los Alamos Scientific Laboratory April 14-16 as part of Science Youth Days.

The students will tour the Health Research Laboratory, Occupational Health Laboratory, the Liquid Waste Disposal Area, Omega Site, Sherwood, Tandem Van de Graaff and the Meson Physics Facility.

Science seniors from Los Alamos High School will participate April 14 and then, for the following two days, a selected number will assist Group ISD-2 as honorary guides.

A former LASL employee, **Roger Ray,** has been named assistant manager for operations at the AEC's Nevada Operations Office in Las Vegas.

Ray recently retired from the U. S. Army with the rank of colonel. In 1953 he was assigned to LASL for nuclear tests at Eniwetok and Bikini Atolls in the Pacific and at NTS. From 1957 to 1958 he was program director of the nuclear test program for Joint Task Force Seven, the military body responsible for conducting high-altitude nuclear detonations prior to a three-year test moratorium initiated in 1958.

Edna Grantham, P-1, retired after more than 24 years with the Laboratory. Mrs. Grantham began working in Group P-1 in 1946. Her husband, William, who works for Zia company, plans to retire in the near future and they intend to make their home in Deming.

The director's conference room has been decorated with many photographs depicting Laboratory activities and scenery. The project was headed by Bill Regan, right, ISD-1 group leader, who was given heavy assistance by Bill Jack Rodgers of ISD-7, shown with Regan in this photograph. The pictures displayed are the work of LASL camermen who were asked to contribute candidate photographs for the project. After selecting appropriate ones for the conference room, they were arranged in panels by Regan and Rodgers in consultation with Hal Olsen of ISD-3. "It will be a changing display," Regan said. "We'll add new photographs from time to time."

Eight years ago science fiction writer Kurt Vonnegut wrapped a novel—"Cat's Cradle"—around a mythical form of ice he called Ice-Nine. Vonnegut entertained his readers with the idea that a small amount of it could be used to transform all the earth's water into Ice-Nine and, in essence, freeze the world.

It was probably no coincidence that Vonnegut assigned a number to this mythical ice because most science fiction takes off from current technology. Scientists have for many years been studying different man-made crystalline forms of ice, each of which is assigned a number, a practice started in the early 1900's by American Physicist Percy Bridgman. Under ultrahigh pressures, Bridgman was able to force the atoms and molecules of ordinary ice into more compact arrangements. By doing this he produced a series of ices not found in nature.

Since then, scientists have continued to prepare and study these ices and from time-to-time have added new forms to the numerical list started by Bridgman. If any of these scientists read Vonnegut's book, they probably gave no more than a passing thought to the possibility of there eventually being a form of ice that would bear the name Ice-Nine.

But as it turned out, five years after Vonnegut's novel hit the marketplace, a Canadian scientist, Edward Whalley added a crystalline form of ice to the list. He took the next number in line and named it Ice-Nine.

What Whalley had done was to explain a peculiarity that had been observed by many scientists. Ice-Three, designated by Bridgman in 1912, could be transformed into Ice-Two by cooling slowly. "Slowly" is a key word in making the transition. If Ice-Three is cooled rapidly, the result is still ice, but it is not Ice-Two. For some time many scientists thought it was still Ice-Three, and others speculated it might be yet another form of ice. But there was no evidence to support either of these views until Whalley noted the hydrogen atoms of the water molecules which constitute the ice recovered at the lower temperature by rapid cooling are arranged in an orderly fashion while those in Ice-Three are disordered, and that the electrical properties of the form named Ice-Nine are different. He also proposed a possible arrangement for its hydrogen atoms.

Several months before Whalley published his findings on Ice-Nine, a small group of scientists at the Los Alamos Scientific Laboratory were also examining the peculiar transition that could be observed by rapidly cooling Ice-Three, and the atomic structure of this and other forms of ice. These studies were conducted by George Arnold and Bob Wenzel, both of P-2, in collaboration with Sherman Rabideau of CNC-2.

Rabideau was one of the first scientists at the Los Alamos Scientific Laboratory to study the various forms of ice and has been at it for several years. "We feel ice studies can tell us something about the way hydrogen bonding can stabilize structures," he said.

Rabideau, Jasper Jackson, now of W-7, and Peter Waldstein who has since left the Laboratory, were the first to record the nuclear magnetic resonance of deuterons (nuclei of deuterium atoms in heavy water) in a single crystal of ice. Both interatomic distances and molecular motion in the ice were revealed by these studies.

In 1966 Ed Finch began working with Rabideau on the structures of high pressure forms of ice. Finch, then of the University of Wyoming, was doing his thesis at LASL under a grant from the Associated Western Universities. During the two years he was in Los Alamos, Finch prepared samples of various ice forms using heavy rather than normal water, a practice followed by many scientists to avoid hydrogen background scattering in diffraction studies of ice phenomena. Although there are slight differences in the substitution of deuterium atoms for hydrogen atoms in water, scientists feel the ice structures are essentially identical.

In 1968 Rabideau enlisted the aid of Arnold and Wenzel to conduct neutron diffraction studies of various ice forms. Neutron diffraction techniques are particularly applicable to locating the positions of hydrogen (deuterium) atoms. Previous x-ray and electron diffraction techniques had been applied by other scientists in locating oxygen atoms in ice. The positions of Ice-Nine's oxygen atoms were determined by Barclay Kamb of the California Institute of Technology in 1960 when it was still thought to be Ice-Three. But the positions of the hydrogen atoms in Ice-Nine and other ices were still only inferred.

In their experiments, Arnold and Wenzel were assisted by Norris Nereson of P-2, and by Al Bowman of CMB-3 who supplemented their studies with computer calculations.

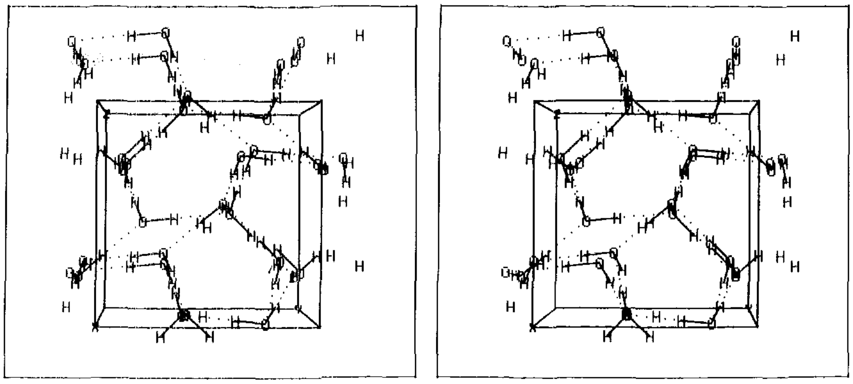
At first Rabideau ground samples of ices into powder so the random orientation of particles would be representative of all planes of the ice crystals. Arnold and Wenzel placed the powders in flat holders and exposed them to a beam of neutrons from LASL's Omega West reactor. The angles at which the neutrons are diffracted by the nuclei of the hydrogen atoms form a pattern which is dependent on the arrangement of the atoms in the sample.

In these initial P-2 studies and all previous x-ray and neutron diffraction work, experiments were done with the various ices in their "quenched" forms. By forcing the atoms and molecules of ice into more compact arrangements and then cooling the ice down to liquid nitrogen temperatures (nitrogen liquifies at minus 317 degrees Fahrenheit) the pressure can be relaxed and the arrangement retained.

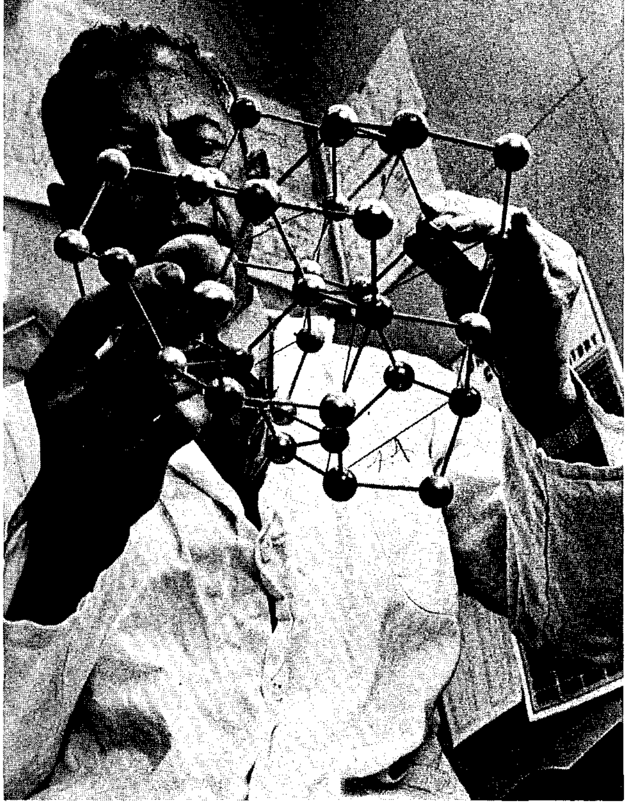
Prior to Whalley's discovery of Ice-Nine, it was thought that all of the high-pressure forms of ice could be quenched. Since the discovery of Ice-Nine, however, there is one exception. This is Ice-Three. When cooled, Ice-Three transforms into either Ice-Two or Ice-Nine. Therefore, the only way diffraction studies of Ice-Three can be conducted is while it is under pressure.

One of the problems in studying Ice-Three or any of the other ice forms while under pressure was that the containers in which they

continued on page 21



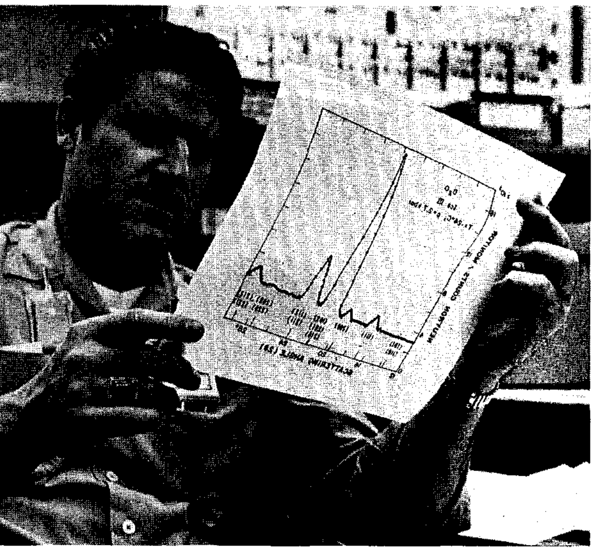
A stereoscopic drawing of Ice-Nine's atomic structure was prepared by Allan Larson of CMB-5. When viewed stereoscopically the right and left drawings merge to give a single three-dimensional representation of the atomic structure. This effect may be observed without a stereoscopic viewer by holding an eight-inch-high piece of cardboard vertically between the two drawings. Then view the drawings from directly over the cardboard so that the left eye can see only the left drawing and the right eye the right drawing.



Sherman Rabideau, CNC-2, explains how an atom of helium could enter the latticework of some of the high-pressure forms of ice and influence diffraction data.

An apparatus was designed in P-2 which allowed scientists to do neutron diffraction studies of ice forms while under pressure. The scientists are Bob Wenzel, George Arnold and Norris Nereson. The enlarged portion of the rod, just below Wenzel's hand, is the sample holder.

Al Bowman, CMB-3, looks at a graph of neutron scattering angles for Ice-Three.



were made were bulky and thick-walled. With containers such as these, diffraction data reflected too much about their wall structures and not enough about the ices they contained.

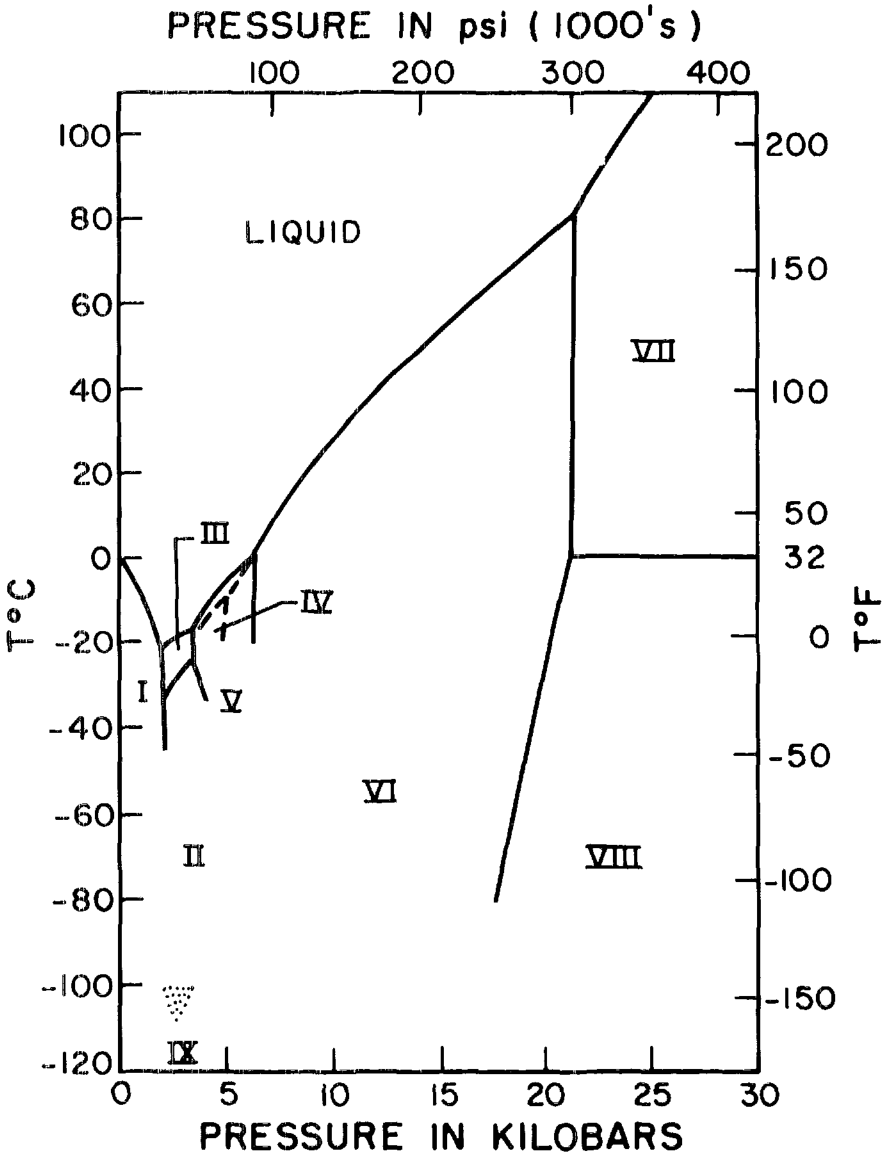
For this reason the P-2 scientists built a vessel whose thin walls would not only allow accurate diffraction measurements of ices while under pressure, but one in which ice samples can be prepared more conveniently. In the vessel, ice is compressed by helium gas. The temperature is controlled by heating and cooling mechanisms built into a heat exchanger which surrounds the vessel. Powdering is accomplished by alternately increasing and relaxing the helium pressure on the ice sample rapidly. This causes sudden changes in volume in the ice and fractures it into powder. For example, to powder Ice-Three, the researchers varied the pressure between that necessary to make Ice-Three and Ice-One (ordinary ice). After the sample is powdered the vessel itself serves as a holder for the neutron diffraction studies.

Helium is not known to have been used before in making high pressure forms of ice. For this reason, some differences in data resulting from the neutron diffraction studies have been attributed to the helium. Among these differences is the pressure required to transform Ice-One into Ice-Three. This transition required 36,500 pounds per square inch pressure compared to 32,500 previously recorded by other scientists. The P-2 scientists also found that after cooling Ice-Three to Ice-Two they could not return directly to Ice-Three. They had to allow Ice-Two to melt and then freeze the liquid to Ice-One before the transition could again be made to Ice-Three. Oddly enough, the transition from Ice-Two to Ice-One occurred at 35,000 pounds per square inch, 1,000 pounds less than it took to go from Ice-One to Ice-Three.

Some data pertaining to Ice-Nine, Arnold, Wenzel and Rabideau feel cannot be attributed to helium pressure. This includes the shape of the Ice-Nine crystal which the scientists found to be almost cubic. It is so close to being cubic, they say, that it qualifies for the crystallographic term "pseudo-cubic." Also, the arrangement of the hydrogen atoms was found to be very close to that proposed by Whalley.

Some variations in results can be expected in any new scientific venture, but all scientists familiar with Ice-Nine will agree there is no way anyone can use it to freeze the world.

The graph shows the approximate temperatures and pressures under which the various high-pressure ices form.



the technical side

Presentation at Niels Bohr Institute, Copenhagen, Denmark, Sept. 1; Oxford University, England, Oct. 20; University of Groningen, Holland, Oct. 22; Atomic Physics Institute, Stockholm, Sweden, Dec. 11:

"Experimental Studies in Nuclear Pairing" by E. R. Flynn, P-DOR

Presentation at the University of Bergen, Norway, Sept. 15, and Oxford University, England, Oct. 21:

"An Automatic Plate Scanner for Nuclear Track Plates" by E. R. Flynn, P-DOR.

Presentation at the Institute of Electrical and Electronic Engineers Meeting, Nuclear Science Symposium, New York City, Nov 5:

"Economic vs. Biological Risk as Reactor Design Criteria" by H. J. Otway, J-DOT, R. K. Lohrding, C-5, and J. B. Burnham, Batelle Northwest Laboratories, Richland, Washington (invited)

Presentation at course on "Selection, Use and Care of Personal Protective Equipment," University of Oklahoma, Norman, Jan. 25-27:

"Respiratory Protective Equipment—Selection, Use, Limitation, and Care" by E. C. Hyatt, H-5 (invited)

Presentation at Simulator Design Symposium, Defense Atomic Support Agency Headquarters, Washington, D.C., Jan. 26-28:

"Current Review of Dense Plasma Focus" by J. W. Mather and P. J. Bottoms, both P-7

Presentation at Department of Physics, Illinois Institute of Technology, Chicago, Jan. 27:

"Flow Microfluorometry: A Rapid Method of Determining DNA Distributions in Cell Populations" by L. S. Cram, H-4 (invited)

Presentation at the Colorado Section, American Nuclear Society Meeting, Boulder, Colo., and Rocky Flats Division, Dow Chemical Company, Golden, Colo., Jan. 29:

"Space Mission Applications of Nuclear Rocket Reactors" by J. D. Balcomb, N-DO

Presentation at the National Bureau of Standards, Washington, D.C., Jan. 29:

"Ultra Low Temperature Nuclear Physics" by J. R. Sites, P-8

Presentation at the American Crystallographic Association Winter Meeting, University of South Carolina, Columbia, Feb. 1-4:

"The Crystal Structure of $CsSb_2F_7$" by R. R. Ryan, CNC-4, and S. H. Mastin, Washington University, St. Louis, Mo.

"Layer Structure Copper Minerals: The Structure of Spangolite" by A. Rosenzweig and C. K. Huang, both University of New Mexico, Albuquerque, and A. C. Larson and D. T. Cromer, both CMB-5

"The Structures of the 1:1 Complexes of CuCN with Pyridazine and with 4-Cyanopyridine" by D. T. Cromer and A. C. Larson, both CMB-5

Presentation at The American Physical Society Meeting, New York City, Feb. 1-4:

"Ultralow Temperature Nuclear Physics" by J. R. Sites, P-8

"Comparison of 54-Manganese and 60-Cobalt Gamma Ray Angular Distribution Thermometers" by J. R. Sites and W. A. Steyert, both P-8, and H. A. Smith, P-2

"Channeling Studies Using a Supercollimated H^- Beam" by H. E. Wegner, Brookhaven National Laboratory, Upton, N.Y., D. D. Armstrong, P-12, and L. C. Feldman and W. M. Gibson, both Bell Telephone Laboratories, Murray Hill, N.J.

"Cross Section for the W-Boson Production Process: Muon Plus Proton Goes to Muon Plus Neutron Plus W-Boson" by H. W. Fearing, T-9, and M. Pratap and J. Smith, both State University of New York, Stony Brook

"Electron Localization in Disordered Systems" by M. Bolsterli, M. Rich and W. M. Visscher, all T-9

"Thermal Conductivities of a Disordered Two-Dimensional Two-Branch Lattice" by M. Rich, W. M. Visscher, both T-9, and D. N. Payton, III, Air Force Weapons Laboratory, Kirtland Air Force Base, Albuquerque

"NMR Study of Na_3UF_8 Structure and Hyperfine Effects" by E. Fukushima, CNC-4, and H. Hecht, CNC-2

"Search for Helium-6 Excited States" by R. H. Stokes, P-12, and P. G. Young, P-3

"Electron Beam Initiation of Large Volume Electrical Discharge in CO_2 Laser Media" by C. A. Fenstermacher, M. J. Nutter, J. P. Rink, all J-18, and K. Boyer, J-DO

Presentation at United Aircraft, East Hartford, Conn. Feb. 2:

"Electron Beam Initiation of Large Volume Electrical Discharge in CO_2 Laser Media" by C. A. Fenstermacher, J-18

Presentation at the Atomic Energy Commission Tamarin Committee Meeting, Hawaii Institute of Geophysics, University of Hawaii, Honolulu, Feb. 3-4:

"Compressible Numerical Calculations of Underwater Detonations" by C. L. Mader, T-3

Presentation at Physics Division seminar, Brookhaven National Laboratory, Upton, N.Y., Feb. 5:

"Energy Levels and Coriolis Coupling in the Odd Tungsten Isotopes" R. F. Casten, P-DOR

Presentation at seminar, State University of New York, Stony Brook, Feb. 5:

"Cross Section for the W-Boson Production Process: Muon Plus Proton Goes to Muon Plus Neutron Plus W-Boson" by H. W. Fearing, T-9, and M. Pratap and J. Smith, both State University of New York, Stony Brook

Presentation at Thomas J. Watson Research Center (IBM), Yorktown Heights, N.Y., Feb. 8:

"Localization of Electron States in Disordered Systems" by W. M. Visscher, T-9

Presentation at meeting of American Academy of Occupational Medicine, New York City, Feb. 8-10:

"Pre-Employment Medical Evaluation by Questionnaire" by G. L. Voelz, H-DO, and J. H. Spickard, Atomic Energy Commission Medical Branch, Idaho Operations Office, Idaho Falls, Idaho

Presentation at the International Atomic Energy Agency International Seminar on Test Requirements for Packaging for the Transport of Radioactive Materials, Vienna, Austria, Feb. 8-12:

"A Mathematical Model for Prediction of Maximum Damage to Shielded Shipping Containers" by B. J. Donham, ENG-DO

Presentation at Brooklyn College, Brooklyn, N.Y., Feb. 9:

"Localization of Electron States in Disordered Systems" by W. M. Visscher, T-9

Presentation at colloquium, Brookhaven National Laboratory, Upton, N.Y., Feb. 9:

"Progress Report on LAMPF" by L. Rosen, MP-DO

Presentation at the Physics Department, New York University, Bronx, Feb. 11:

"Radiation from a Beam of Test Electrons" by D. W. Ignat, P-13

Presentation at the 11th Annual Symposium in Experimental Mechanics, jointly sponsored by New Mexico Sections of the American Society of Mechanical Engineers, the Society for Experimental Stress Analysis, and the College of Engineering, University of New Mexico, Albuquerque, Feb. 11-12:

"Strain Measurements at Extremely High Temperature Using Moiré Fringe Techniques" by J. W. Neudecker, Jr., N-7 (invited)

Presentation at Symposium on "Peacetime Uses of Atomic Energy" sponsored by the New Mexico Academy of Science, University of New Mexico, Albuquerque, Feb. 12:

"The Meson Facility" by L. Rosen, MP-DO

Presentation at the 15th Annual Meeting of the Biophysical Society, New Orleans, La., Feb. 15-18:

"Mathematical Model of the Immune Response—Application to the Induction of Immunological Paralysis" by G. I. Bell, T-DOT

"Characterization of RNA Obtained from 10-30S Post-Ribosomal Particles" by A. E. Hampel, Northern Illinois University, DeKalb, and A. G. Saponara, M. D. Enger and R. A. Walters, all H-4

"A Chemically-Defined Substrate for the Photoreactivating Enzyme **In Vitro**" by D. L. Williams and F. N. Hayes, both H-4, and A. J. Varghese and C. S. Rupert, both Division of Biology, University of Texas, Dallas

"An Electronic (Coulter) Particle Counter for Use in Animal Injection Experiments" by P. F. Mullaney, H-4, and J. R. Coulter, SD-5

"Radiosensitivity of Histone Turnover and Phosphorylation" by L. R. Gurley and R. A. Walters, both H-4

"DNA Distribution of Cell Populations: Computer Analysis of Flow Microfluorometric Measurements" by M. A. Van Dilla, P. N. Dean and T. T. Trujillo, all H-4

"Fluorescent Spheres for Cell Population Modeling in Automated Cell Analysis Systems" by L. S. Cram, M. J. Fulwyler and J. D. Perrings, all H-4

"Failure of X-Irradiation to Inhibit DNA Replication" by R. A. Walters, R. A. Tobey and L. R. Gurley, all H-4

"Initiators for Replication of Synthetic Single-Stranded Polydeoxynucleotides" by F. N. Hayes, R. L. Ratliff and D. A. Smith, all H-4

Presentation at Nuclear Engineering Department, Kansas State University, Manhattan, Kan. Feb. 16:

"Time - of - Flight Measurements with Nuclear Explosions" by M. S. Moore, P-3

Presentation to the American Nuclear Society, Idaho Falls, Idaho, Feb. 18:

"On the Nature of Ball Lightning" by J. L. Tuck, P-DO

Presentation at seminar, National Reactor Testing Station, Argonne National Laboratory, Idaho Facilities, Idaho Falls, Idaho, Feb. 19:

"Review of Controlled Fusion and Its Objectives" by J. L. Tuck, P-DO

Presentation at seminar, University of New Mexico, Albuquerque, Feb. 19:

"Status of Anomalous Water Research" by S. W. Rabideau and A. E. Florin, both CNC-2 (invited)

Presentation at Physics Seminar, Stanford University, California, Feb. 19:

"Single Particle Transfer Reactions and Coriolis Coupling in the Odd Tungsten Isotopes" by R. F. Casten, P-DOR

Presentation at seminar, Physics Department, Colorado State University, Fort Collins, Feb. 19:

"Exotic Resonances" by R. R. Silbar, T-9

Presentation at seminar, Nuclear Engineering Department, University of New Mexico, Albuquerque, Feb. 19:

"Inert Gas Bubbles in Solids" by F. W. Clinard, Jr., CMB-5

Presentation at the University of Alabama, Birmingham, Feb. 22:

"Flow Microfluorometry: A Rapid Method of Determining DNA Distributions in Cell Populations" by L. S. Cram, H-4 (invited)

Presentation at the Computer Science Departments, Southern Methodist University, Dallas, Texas, Feb. 23; Georgia Institute of Technology, Atlanta, Feb. 24, and Symposium on Data Structures in Programming Languages, University of Florida, Gainesville, Feb. 25-26:

"Generalized Data Structures in Madcap VI" by J. B. Morris, Jr. and M. B. Wells, both C-7

Presentation at Research Seminar, Sandia Laboratories, Albuquerque, Feb. 24:

"Applications of the Ice Method to Studies of Atmospheric Explosions" by R. A. Gentry, T-3

20 years ago in los alamos

Culled from the April, 1951, files of the Los Alamos Herald by Robert Porton

Residents to Tour South Mesa Projects

Local residents will be permitted for the first time to inspect two new scientific projects behind the security fences on South Mesa. All persons holding town passes with the letter "Z" preceding the numbers, will be allowed to visit the new Van de Graaff accelerator, housed in one of the tallest buildings in New Mexico, and the Ten-Site laboratory. "The purpose of this program is to give Hill employees and their families an opportunity to see some of the new technical facilities being built for the Laboratory," the announcement stated.

SFO Headquarters to Albuquerque

The Santa Fe Operations Office of the Atomic Energy Commission will be transferred to Albuquerque, by mid-July, it was announced by Carroll L. Tyler, SFO Manager. Tyler said "some 230 positions will be established in the Albuquerque headquarters. The move is being made for reasons of both efficiency and economy. With the top level command moving from the Hill, Los Alamos will become a field operation, probably under the directorship of Elmo Morgan, Tyler's assistant."

Closer Check on Passes and Badges

Starting next week, Los Alamos residents and workers will no longer be permitted to "flash" their passes and badges. They'll have to hand them to the Protective Force guards for a longer, closer look. This announcement from the AEC's Security Branch asserted that a trial period of manual checking proved to be very beneficial from a security standpoint.

Chief's Car is "Stolen"

"This just bears out what I've been saying for a long time—people shouldn't leave their keys in cars." So spoke red-faced Police Chief Ralph Kopansky after his unmarked police car had been "stolen" from a community center parking lot. Kopansky saw his car being driven away by a stranger and sounded the alarm. What had happened was this—H. E. Pickett, Zia Company supervisor, drives a car identical to the chief's. He parked beside Kopansky's vehicle. You guessed it—he drove off in the wrong car. The comedy of errors finally came to an end but it will be a long time before Chief Kopansky will be allowed to forget the incident.

what's doing

PUBLIC SWIMMING: High School Pool—Monday through Wednesday, 7:30 to 9 p.m., Saturday and Sunday, 1 to 6 p.m.; Adult Swim Club, Sunday, 7 to 9 p.m.; Women only, (sponsored by American Red Cross) Saturday, noon to 1 p.m.

SIERRA CLUB: Luncheon meeting at noon, first Tuesday of each month, South Mesa Cafeteria. For information call Brant Calkin, 455-2468, Santa Fe.

RIO GRANDE RIVER RUNNERS: Meeting scheduled for noon, second Friday of each month at South Mesa Cafeteria. For information call Joan Chellis, 662-3836.

INTERNATIONAL FOLK DANCING: Every Tuesday at the Recreation Hall. 8 p.m.—beginners instruction. 9 p.m.—regular dancing. For information contact Joseph Devaney, 662-5658 or David Barfield, 662-6236.

OLD TIMERS SQUARE DANCE CLUB: Second and fourth Saturday of each month, 8:30 p.m., YMCA. For information call Frances Hollinrake, 662-5898.

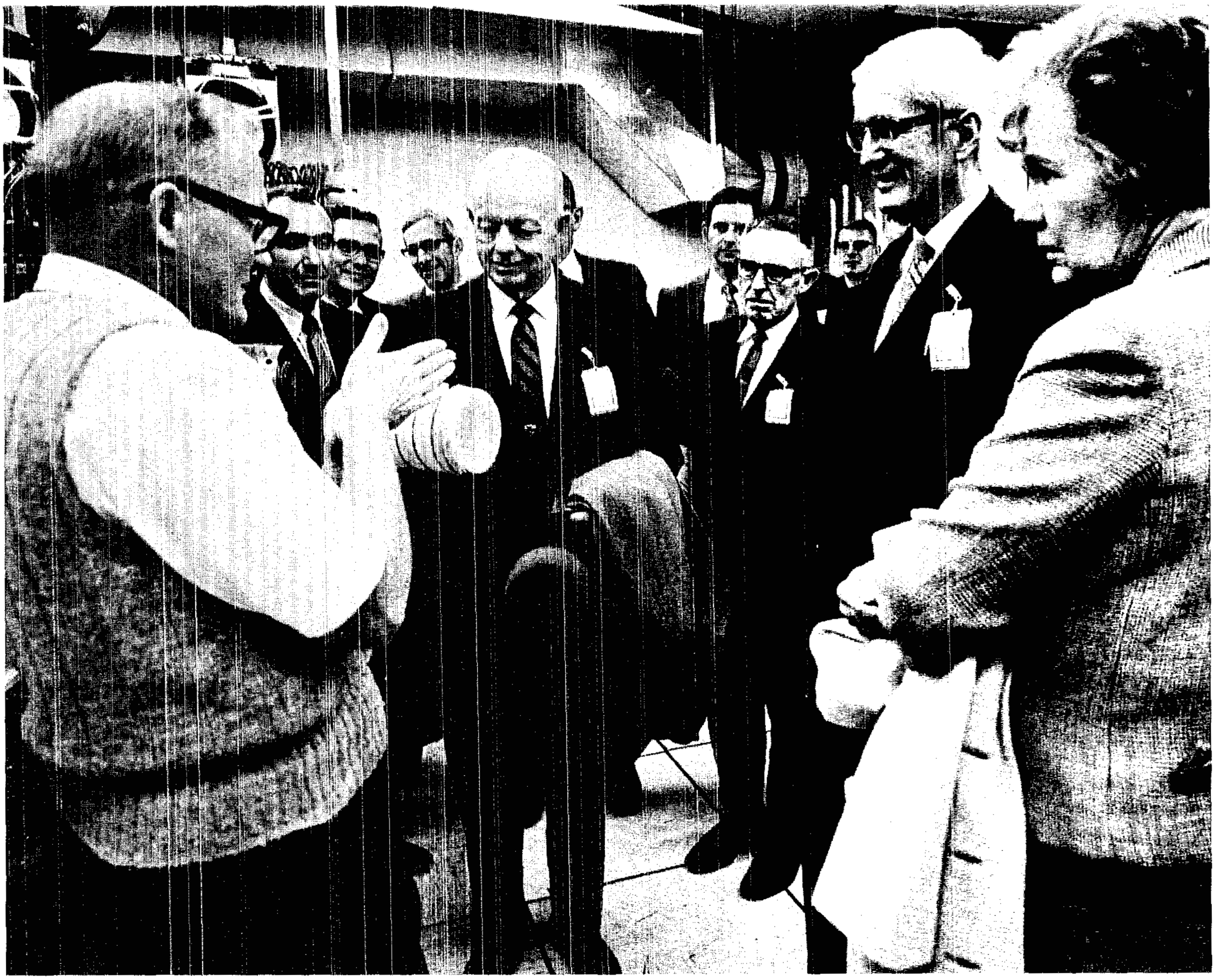
MOUNTAIN MIXERS SQUARE DANCING: For information call Mrs. Dee Seitz, 662-7356.
April 3—Canyon School, 8 p.m., Ken Hostettler, Albuquerque, caller.
April 16—Canyon School, 8 p.m., Fred Steaben, Palmer Lake, Colo., caller.

OUTDOOR ASSOCIATION: No charge, open to the public. Contact leaders for information regarding specific hikes.
April 18—San Juan to Otowi, Ken Ewing, 662-7488

NEWCOMERS CLUB: April 28, 7:30 p.m., Los Alamos National Bank: Jann Szalay, directress, School of Charm and Modeling, "Make the Most of Yourself."

MESA PUBLIC LIBRARY:
April 1-27—National Library Week exhibit
April 1-21—"Artists' Choice," Museum of New Mexico traveling exhibit
April 1-14—Narcotics display
April 21—May 18—Paintings, Mary Lena Burke, Clovis
April 14—April 28—Handmade Jewelry, Martha Best

LOS ALAMOS FILM SOCIETY: 7:30 p.m., April 28, Civic Auditorium. Admission: members—$.50, others, $3. "The Battle of Algiers."



James Phillips, P-14 group leader, explains to the Atomic Energy Commission's General Advisory Committee how the Shock Heated Toroidal Z-pinch device will work. The device is one of the Sherwood Program's newest approaches aimed toward controlling a thermonuclear reaction.

Henry T. Motz
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Los Alamos, New Mexico 87544